# Axial Distribution of Vacancy-Type Defect Evolution Along an n-Doped GaAs Boule: A Positron Lifetime Spectroscopy Study

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**Abstract:** Positron annihilation lifetime spectroscopy (PALS) was used to characterize vacancy-type defects in n-doped GaAs single crystal grown as dedicated boule for defect–dopant correlation studies. The axial distribution of the dopant was quantified by GDMS, and the corresponding axial evolution of free carrier concentration was established from the Hall measurements. Selected axial positions were investigated by positron lifetime spectroscopy to probe open-volume defect populations and to test for a link between doping and vacancy-type defect concentration. The measured average positron lifetimes increased from 238 ps at lower dopant concentration to 244 ps at the tail of the crystal, indicating an increasing contribution of vacancy-related positron trapping relative to the GaAs bulk lifetime (~229–231 ps). A strong linear correlation ($R^2$ = 0.92) was obtained between the PALS-derived vacancy concentration and the GDMS dopant concentration. Within the sensitivity of the lifetime analysis, the dominant vacancy signal remained consistent with a monovacancy-like open volume, with no evidence for an additional lifetime component attributable to larger vacancy complexes. In contrast to prior PAS studies on n-doped GaAs that identify specific dopant–vacancy complexes as dominant under highly n-type conditions, the present results provide a quantitative, axial metrology link between absolute dopant incorporation and vacancy-type defect concentration in a single growth run, enabling direct process-relevant constraints for defect engineering in heavily doped GaAs.

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